Beltsville Human Nutrition Research Center

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- Approximately 200 employees; 60 doctoral level scientists
- Largest of six ARS human nutrition research centers (budget: $20M appropriated + $5M extramural)
- Located at a comprehensive agricultural research facility: BARC

What are Functional Foods?

Food similar in appearance to conventional food that is intended to be consumed as part of a normal diet, but has been modified to subserve physiological roles beyond the provision of simple nutrient requirements

M. Roberfroid (2000) *Functional Foods: Concept to Product*

Simplest definition: Foods that may provide health benefits beyond basic nutrition

Types of Functional Foods

- Fortified products (increasing the content of existing nutrients)
- Enriched products (adding new nutrients or components)
- Replacing existing components
- Enhanced commodities

How could we enhance the food supply?

Existing Nutrients

Nutrient	RDA	Safe Limit
Calcium	1200 mg	2 X
Iron	15 mg	5 X
Iodine	150 ug	13 X
Selenium	70 ug	13 X
Vitamin C	60 mg	16 X
Vitamin B6	2 mg	125 X
Folic Acid	400 ug	50 X
Vitamin E	10 mg	100 X
Vitamin A	1 mg	5 X

α-Tocopherol, β -Carotene Cohort Study – Lung Cancer

	Relative Risk
Fruit/Vegetable Consumption	0.73
Lycopene	28%
Lutein/zeaxanthin	17%
Beta-cryptoxanthin	15%
Total carotenoids	16%
Serum Beta-Carotene	19%
Serum Retinol	27%

Study of 27.084 smokers, 50-69 years of age. Results of dietary survey.

Holick, et al. (2002) Am J. Epidemiol. **56**, 536-547

α-Tocopherol, β -Carotene Cohort Study – Heart Disease

Treatment	Relative Risk
β -Carotene	1.75
α-Tocopherol	1.33 (NS)
α-Tocopherol + β -Carotene	1.58

Rapola et al. Lancet (1997) 349: 1715-1720

CARET Study

- 30 mg beta-carotene and 25,000 IU retinyl palmitate daily
- 1831 men and women (smokers)
- Intervention stopped at 21 months
  - 28% more lung cancer
  - 17% more deaths

Omenn *et al*. (1996) J Natl Cancer Inst **88**, 1550-1559

Relationship Between Diet and Health

Overall Diet

Individual Foods

Particular Food Components

Strongest Link

Weakest Link

Enhanced Commodities

- Golden rice: introduced β-carotene biosynthesis pathway into rice by genetic engineering
- Enhanced production of vitamin E
- Nu-Sun sunflower oil: Overproduction of oleic acid in sunflowers

Probiotics

- Live microbial food ingredients that have a beneficial effect on human health
- *Lacotbacillus* sp.
- *Bifidobacter* sp.
- Traditionally found in fermented dairy products but also in fermented vegetables

Prebiotics

- Provide a GI environment in which beneficial bacteria can thrive
- Fermentable dietary fiber (oatmeal, flax, barley, whole grains, fruits vegetables and beans)

Health Effects of Pre/Probiotics

- Balance between harmful and beneficial bacteria
- Lactose intolerance
- Improved digestion
- Enhance immune response
- Cholesterol lowering
- Reduced cancer of the GI tract

Fructooligosaccharides

- Oligofructose and Inulin
- Nondigestible carbohydrates: reach colon intact
- Specific substrates for *biofidobacter* sp.
  - Inhibits growth of other bacteria
  - Lower pH; increased short chain fatty acid production
- Improved bioavailability of Ca, Mg, and Fe
- Hypolipidemia; cholesterol lowering
- Immunomodulation
- Lower ammonia levels in GI tract
- Production of vitamins

Effect of Plant Sterol Esters on Cholesterol Levels

Treatment	LDL Chol	HDL Chol	TG
Control diet	↓7.9%	↓3.1%	↓9.3%
3.6 g/d PSE	↓17.6%	↓3.1%	↓16.6%

26 Men and 27 women fed isocaloric diets (32% fat) for three weeks with two servings of salad dressing per day.

Judd et al. (2002) *Lipids* 37: 33-42

Soy Protein

- Soy protein has lipid lowering abilities
- Presumably due to isoflavone content
- Isoflavone isolate from soy protein not as effective as intact protein
- Studies from BHNRC did not see expected effect: must be part of low fat diet and also great individual variation

Oatrim Studies

- Oatrim is a high fiber fat substitute developed and licensed by ARS
- Can substitute for 50% of the fat in foods
- Increased fiber
- Improved glucose tolerance
- Weight loss
- Reduced fat

How do we know that a particular nutrient is beneficial?

- Epidemiological studies
- Diets do not exist in isolation
- Will enhancement produce the desired effect?
- Will the product be consumed?
- Safety issues?
- Costs

Nutritional Issues

- What are the active components in foods?
- A deficiency might be harmful but excess is not necessarily good
- What is the effect of overall diet?
- Are there any negative effects of functional foods?

Functional Foods and Obesity

- Has to be part of an overall diet and behavioral modification
- Confusion about best approach
- Enhance essential nutrients
- Restrict calories
- Maintain or increase volume

How **should** we enhance the food supply?